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XLIV.—*On the Anatomy and Physiology of the Vorticellidan Parasite* (Trichodina pediculus, *Ehr.*) *of Hydra.* By Prof. H. James-Clark, A.B., B.S.*

[Plates VIII. & IX.]

There can be no doubt that a large amount of the diversity of opinion in regard to the general and classificatory relations of animals arises from the lack of a correct knowledge of the intimate structure of the subject under controversy. This is especially applicable to the lower forms of life, and above all to the fifth and lowest grand division of animals—the Protozoa. Theories which are based upon insufficient observations and a misconception of facts not only present a distorted view of nature, but mislead and give a wrong direction to the tendencies and currents of scientific research. The theory of the unicellular nature of Infusoria—so acutely upheld by the arguments of Siebold and Kölliker, and especially by the latter in his papers on the Gregarinidæ† and on *Actinophrys*‡—had no small influence in blinding the mental vision of subsequent investigators, and long delayed the conclusion (strangely enough, too, seemingly favoured by Kölliker himself) that it is not essential to the constitution

* From the memoirs read (Oct. 18, 1865) before the Boston Society of Natural History, vol. i. part 1. Communicated by the author.

† Beiträge zur Kenntniss niederer Thiere (Zeitschr. für wiss. Zool. Bd. i. (1848–49) p. 1.

‡ Das Sonnenthierchen, *Actinophrys sol* (Zeitschr. für wiss. Zool. Bd. i (1848–49) p. 198. In some remarks upon *Actinophrys* which I took occasion to make at a meeting of the Boston Society of Natural History (see Proceedings for September 16, 1863), I stated that the so-called vacuoles of the Actinophrys (*A. Eichhornii*) are "true cells with a distinct wall about them." In a new work (Mind in Nature; or, The Origin of Life and the Mode of Development of Animals: New York, 1865) just issued from the press, I have reiterated this statement, and given still further details of the anatomy and physiology of *Actinophrys*.

of a *cell* that it should possess a tangible, distinctly differentiated envelope.

At the present day we may safely consider every one of the minutest centres of organic development and action as so many individual cells (not only potentially, but as essentially so as are any of the most decidedly wall-bound cells of the highest kind of tissue), and yet not become liable to the accusation of leaning toward a visionary method of investigating or interpreting the phenomena of nature. It really seems as if the much-abused spirit of Oken were about to have its revenge, and the prophetic vision of that immortal genius were soon to be realized by the eyes of the philosophers of the present day. Happily, among the rising generation of the naturalists of this country, a growing independence of thought and action—too long under the shade of the upas tree of fictitious authority, and allured by the deceitful and fascinating exterior of superficial, glittering, swift, and hasty generalization—is leading to this result with rapid strides.

Neither the genius of a Spencer nor the incomparable ingenuity and tact of a Tolles are able to increase the availability of the microscope as rapidly as the requirements of scientific progress demand; and if one would see beyond the mere optical image of the instrument, he should, by careful and judicious treatment, train the eye to develope to the requirements of the occasion. It must become to him a sliding-scale of adjustable optical powers. The tutored eye of Ehrenberg saw far more than the microscopes of his earlier days could help him to discern. The truth of this is especially observable in the surpassing naturalness and life-like character of his illustrations, so often superior to the delineations of his more modern compeers. When we have combined the effect of the former with the more accurate details of the latter, we shall then, and not till then, have arrived at an honest representation of animal life, and have laid a firm foundation for a series of deductions and generalizations whose influence shall be felt beyond the brief flitting period in which they were produced.

That investigation which, although confined within a narrow circle, is the most thorough, and at the same time truthfully recorded, is far more valuable for the future than a course of observations which extends over a larger field and is carried out on a grander scale, but lacks the element of completeness. A thorough and elaborate study of one single species will carry the possessor of such knowledge immeasurably deeper into the secrets of life, and inconceivably further along the road of progress, than a superficial, lightly tripping survey of the whole kingdom of animals. In the former case, for each newly dis-

covered fact the naturalist takes one step higher on the hill of science, whilst in the latter he is for ever trying to get the first foothold in the ascent.

Of all the Protozoa, there are none which have so great a claim upon the naturalist's time for investigation as the Vorticellidæ. The want of a precise understanding of their structure led, in the first place, to their being classed with the Zoophyta, and (simply on account of their similarity in form) among the Hydras. This was the first retrocession. After Ehrenberg had promulgated the opinion that they possessed a distinct intestine, whose two ends approximated each other, we find Van der Hoeven, in the second edition of his 'Handbook of Zoology,' comparing them to the Bryozoa, and avowing his belief that their future place will be among the lowest groups of Mollusca. Here we have a still deeper plunge into the vortex of confusion—not so much, however, if at all, to the discredit of the Dutch naturalist as to that of those who came after him. The apparent similarity of the organization of the Vorticellidæ to that of the Bryozoa was no small warrant for his suggestion; but after almost every microscopist of any degree of reliability who looked at these infusorians had disproved and denied the presence of the intestine so elaborately set forth by the Berlin micrographer, and nothing was left but a mere resemblance in outward form to the Bryozoa, it was, to say the least, a very far-fetched comparison when Professor Agassiz homologized them with the Mollusca, declaring that he had satisfied himself of the "propriety of uniting the Vorticellidæ with Bryozoa."

Ere this, too, Lachmann (Müll. Archiv, 1856) had shown that the whole group of ciliated Infusoria possess a conformity of organization altogether unlike that of any other. The profound researches of this early-lamented observer left no doubt as to the dissimilarity between the Vorticellidæ and Bryozoa. Here was, at last, a step taken in the right direction; and when this author, in connexion with Claparède, published the 'Etudes sur les Infusoires et les Rhizopodes,' the climax of proof was attained in the abundance of details presented in that remarkable volume. Among the many questions which are discussed in that work, that of the unicellularity of the Infusoria receives a considerable share of attention; and a decided ground is taken in favour of their *pluricellularity*—not so much, however, on account of their being known to consist of more than one cell as of the fact of their possessing such a variety of organs and performing so many diverse functions.

The greatest variety of this kind is most elaborately exemplified by the group of Vorticellidæ; but yet it rises, from the lowest of the class, through such insensible grades, that the

relations of the type and of the two extremes are never lost sight of amid the growing complexity of the organization.

Among the many forms which more than usually excite the interest of the observer, there is no one in the whole class of Protozoa that surpasses the allurements of the remarkable creature which forms the subject of the present memoir. This is accounted for by a twofold reason,—in the first place, because it possesses such an unlooked-for degree of complication in its organization; and secondly, because it seems to stand intermediate between the two great groups of Ciliata—the *dexiotropic* on the one hand, and the *lævotropic* on the other. The transitional forms in all departments of the animal kingdom are eminently suggestive, but none more so than the genus *Trichodina*. Combining in one animal the typical forms of two groups, and yet so singularly individualistic as to be confounded neither with the one nor with the other, the elaborate solution of the relations of the various members of its organization to each other, and the tracing of their homologies with those of the groups on either side, engage the attention no less deeply, and none the less worthily, than if it were occupied in the investigation of the most profound philosophical problem.

An attempt, therefore, at a full life-history of this animal becomes an effort at something more than a mere specific description without an aim; and whatever apparent triviality of detail there may seem to be in it, the consciousness that no one part of an organization is without relation to some other part leads the author to the opinion that an investigator should never undertake to assume what is of importance and what is not. It is no unfrequent occurrence that what at one time has been deemed worthy of very slight consideration, becomes at another the paramount object in a course of scientific research. Nature is not to be represented in full detail by the broad touches and counterfeiting portraiture of a Vandyck, howsoever striking and suggestive the likeness may be; in order to bear a closer inspection, her image must needs be mapped and copied by the more matter-of-fact hand of the humbler Flemish artist.

§ 1. Habitat.—This species (Pl. VIII., *Trichodina pediculus*, Ehr.) is found in great abundance creeping over the body, and even to the tips of the tentacles, of our common brown and green freshwater Hydras (*H. fusca* and *H. viridis*, Trembley). Oftentimes it may be seen with the middle of its base applied directly over the centre of a group of nettling-organs, the former fitting the latter like a cap, and without seeming to disturb the Hydra in the least.

Notwithstanding the apparent rigidity of the chitinous uncinate ring of the base, the latter possesses the greatest degree of

flexibility, and an unlimited adaptability to whatever surface it may come upon, no matter how uneven it happens to be. The intimate structure of the chitinous ring does not interfere in the least with, but on the contrary appears to assist in, the flexures of the base. The latter is always the point of attachment; and upon this part of the body the animal may be seen, almost at all times, gliding to and fro like a miniature cup (figs. 1, 2), now on the upper side of a Hydra, and then on the lower side. At one moment several individuals are crowded together on a tentacle, and in the next instant scattered along its length from base to tip, and giving to it a singular, irregular, changeable outline. At times the Hydra seems to be strangely knotted, and ungainly in outline, when, upon close examination, we ascertain that it is crowded with a swarm of Keronas, upon several of whose convex backs one, two, or three Trichodinas are seated, enjoying the pleasure of locomotion without the effort of producing it. Not unfrequently an individual may be seen to leave its reptant mode of progress and take to the surrounding element. Then it swims, at times very swiftly, either in a fully expanded state, or half expanded (fig. 4), or even shortens its length so much that its body resembles a wheel (fig. 5) rolling on its axis, or turning end for end and performing a series of somersaults with great rapidity. Presently it returns to its more quiet mode of life, sliding spectre-like over the animate surface which forms its principal field of operations. During its act of reptation it revolves very slowly upon its longitudinal axis, as if upon a pivot, and most frequently, if not always, wheels to the right.

§ 2. Specific Relationship.—When looking at perfectly fresh and lively specimens of this Infusorian, one can hardly believe, at first, that their deep, cyathiform, dicebox-like bodies (figs. 1, 2) are specifically identical with the straight and broad cylindrical forms which are figured by Ehrenberg and Dujardin, or with the turban-shaped bodies which are illustrated in the papers of Stein and Busch; but when, upon prolonged investigation, we see that the least interference with their freedom of motion causes them to assume a depressed form and a partially retracted margin, we recognize their close resemblance, at least, to those of the above-named authors. The former state represents nature in reality; the latter exhibits her in a disguised shape. It is therefore with no small degree of reluctance that one concludes to identify the flexible, irregularly funnel-shaped, conspicuously asymmetrical body of the American Trichodina with the seemingly stiff, precisely outlined, cylindrical or conical figures illustrated in European works; but a careful study of this under various conditions, both in re-

gard to space for movement and the quality of the water, inevitably leads to the conclusion that the European figures represent the creature in an abnormal, or at least a more or less restrained condition, certainly not in a perfectly healthy state.

If a Hydra, upon which some of these animals are living, is transferred to a flat watch-glass, and the water is frequently renewed, there is not the least difficulty in studying this Infusorian whilst in its fullest degree of expansion, and even with a magnifying-power of at least five hundred diameters. In fact it is absolutely necessary that the body should be fully expanded, in order to understand the relation and nature of certain parts of its organism—especially the vestibule and œsophagus, and the contractile vesicle. In a semiexpanded state of the body these parts are confused, and it becomes impossible to ascertain their character with even the least degree of satisfaction. It is on this account that neither the figures of Stein nor those of Busch give the faintest idea of what the anterior region of *Trichodina* is like; and we actually get a better and truer impression of its character from the almost forgotten illustrations of Ehrenberg than from the more modern and what ought to be more correct delineations of this animal.

§ 3. Form.—The form of the body is like that of a heavy wine-glass (figs. 1, 2, 8, 14) with a very thick and but slightly expanded base. The plane of the margin of the front, *i. e.* the peristome (d^1), lies parallel with that of the base, or "adherent organ," and nearly at right angles to the axis of the body. The *disk* (c, c^1), or area encompassed by the vibratory crown (b), is deeply depressed, so that the anterior end of the body, not only externally but internally, is truly *cyathiform.* In fully expanded individuals the depression of the disk extends nearly to half the depth (at c) of the body, and occupies at least nine-tenths of the diameter of this region. At times the animal suddenly recurves the edge of the cup nearly back to its base, and exposes the bottom of this hollow in a most convincing manner (fig. 6). In partially contracted individuals (fig. 10), the bottom of it becomes elevated, and projects like a boss (c) more or less beyond the inrolled vibratile organ (b). This is the condition (with the vibratory cilia more or less projecting) of those figured by all observers, and especially by Stein and Busch, and a form which the creature very frequently assumes when in a confined state.

It is an easy matter to see that their natural and accustomed shape is as we have represented these animals—if one studies them undisturbed, as they creep over the body of a Hydra which is attached to the side of an aquarium. With a Wollaston doublet, magnifying thirty diameters, or even a Tolles triplet, magnifying

seventy diameters, one may, with great facility, survey, through the glass sides of an aquarium, the whole body of a Hydra, and watch the movements of the Trichodinas which infest it. Under these conditions it is no exaggeration to say that it is very rare to meet with a Trichodina whose disk protrudes (and that only momentarily) beyond the plane of the vibratile crown; on the contrary it is sunken far below this plane, thus rendering the region about this part of the body singularly transparent, light, and airy. This effect is very much enhanced, moreover, by the excessively transparent filmy exterior wall (*p*) which projects, very prominently in profile, between the two ends of the body.

The contour of the body behind the spiral vibratile crown (*b*) is singularly irregular, especially in a transverse direction. A sectional view (fig. 9) presents the form of an irregular circle with various projections, inwardly and outwardly, from its main course. This arises from the fact that the body is fluted and ribbed exteriorly by irregular longitudinal furrows and projections (Pl. IX. fig. 14, *r*, *r*), which extend from one end of it to the other. The ribs (*r*) arise with a broad expanse immediately behind the anterior ciliated margin (d^1), and gradually narrow toward the mid length, and then more gradually expand to a much less width at the posterior end. At first one is impressed with the idea that they are longitudinal muscles; but as they are more carefully examined, they do not appear to be anything but mere thickenings and folds of the body-walls.

The principal cause of the one-sidedness of the body is the protrusion of the region (figs. 8, 11, 13, *d*, d^3) about the mouth (*m*) of the vestibule (*v*), transforming the circular outline of the vibratile organ (*b*, b^1) into a broad oval figure when this ciliated margin is foreshortened (fig. 13) and brought into focus with that part which winds spirally downwards and into (at b^2) the aperture of the vestibule. In the form of the disk, and the circumambient spiral vibratory crown, we are reminded rather of *Stentor* than of the Vorticellidæ; nor would it be amiss to suggest here that, in this respect, *Trichodina* stands intermediate between the Vorticellidans and the group (Bursarinæ) to which *Stentor* belongs.

Owing to the presence of the reproductive organ (*n*), and the so-called "adherent apparatus" (fig. 10, *h*, *i*, *l*, l^1), the expanded circular base is even more conspicuous than the discal end. It most frequently presents itself as a rather abruptly widening, perfectly circular, disciform expansion whose plane trends transverse to the axis of the body. It varies in form more or less, according to the surface over which it is creeping—at one moment sunken (fig. 14) like a cast into a depression of the

body of the Hydra, and at the next instant assuming the reverse form (fig. 10), and embracing some projecting group of cnidæ, or as it were wrapped around the parietes of an extremely elongated tentacle. As a further extension, the base is margined by an annular membrane, or *velum* (f, f^1), and a single row of cilia (g); both of which serve to render it more conspicuous, and give to this region of the body the appearance of greater weight and firmness.

§ 4. The Prehensile Organs.—The motory organs appear to be divided into two groups, of which one is very active in character, and the other is comparatively passive and resistant. The members of the former group are the vibratile cilia and *velum*; and those of the latter constitute the "adherent organ."

The vibratory crown.—The vibratile cilia occupy two widely separate parts of the body, in one place fulfilling the office of purveyors of food, and in the other acting as organs of locomotion in the strictest sense. The former are the true prehensile organs, and, with the margin to which they are attached, constitute the so-called "*vibratory crown*" (b, b^1, b^2). This organ lies, in the form of a nearly flat spiral, at the anterior end of the body, and borders the edge of the cup, which forms the principal part of the front. It therefore rests on the periphery of the *disk* (c, c^1, c^3), so that a delineation of the one defines the contour of the other. The spiral commences (b^1) at the extreme right of the front, and, sweeping around ventrally and just before the edge of the mouth (m) of the vestibule (v), passes to the extreme left, and thence along the dorsal edge of the cup, whence it passes toward its starting-point on the right, but a little exterior to it, so as to overlap it. Thus far it follows the edge of the cyathiform disk, and forms a distinct border throughout its circumference; but in passing to the termination of its course it runs along the extreme brink of an inclined plane (figs. 11, 12, c^4) which rests on a cornice-like projection that extends obliquely across the body, from the right, slightly backwards, toward the left, as far as the aperture (m) of the vestibule, and then rapidly narrows and becomes blended (fig. 13, d^4) with the body beyond. In fact the vestibule (v) is buried for its major part in this oblique projection, and opens at the widest or terminal part of the inclined plane which forms the anterior face of the latter. Consequently the vibratory crown, when following the border (d^3) of this plane, passes exterior to, and along the ventral side of, the aperture of the vestibule, but, instead of going beyond it, gradually approximates to it, and finally entering at its left side, and taking an oblique course toward the right, plunges to its very bottom, in one unbroken, single line (Pl. IX. fig. 13, b^2).

In the true Vorticellidæ the disk is a prominently marked

organ, and is more or less elevated above the annular peristome whereas in the *Trichodina* before us the peristome (d, d^1, d^3, d^4, d^5) is not a closed circle, but is blended with the spiral margin of the disk (c, c^1, c^3, c^4); or rather the *disk*, instead of projecting beyond the rest of the body, is sunken (c, c^1)—invaginated, as it were—and has a deep cyathiform contour, and its margin is only separated from the peristome (fig. 15, d^1) by the slight furrow (b^3) in which the cilia (b) of the vibratory crown are implanted. This relationship is strikingly exemplified in another way; for when the animal is contracted (fig. 10) and the peristome (d^1, d^2) rolled inwardly, the vibratile row of cilia (b) is not to be found at the bottom of the enclosed space, as is the case when the like phenomena occurs in *Vorticella, Zoöthamnium, Carchesium,* and *Epistylis,* but hangs down into that space, like a fringed curtain, from the inrolled edge of the peristome. The distinction between disk and peristome is therefore no more marked than in *Stentor*; and, in consequence of the relation of the two, the peristome, instead of traversing the ventral side and forming a complete ring as in the true Vorticellidæ, descends, with the vibratile organ, to the mouth of the vestibule, and then vanishes in the general surface of the body.

The vibratile cilia (b) of this organ are very long and slender thread-like bodies, which stand in close rank, in a single row. They arise from the bottom of a slight furrow (fig. 15, b^3) which extends along the inner side of the peristome (d^1), from its beginning (b^1) on the right, throughout its first turn (d^3), and thence to its termination (d) at the left margin of the aperture of the vestibule. They usually incline in the direction which leads toward the mouth and along the margin of the disk (*i. e.,* throughout the extent of the first turn of the spiral), and they at the same time spread outwardly as if in continuation of the curve of the cup; but occasionally they incline toward the centre of the depressed disk, and produce a vortex therein by their combined action.

The œsophageal cilia.—The vibratile cilia which line the œsophagus (o, o^1) and seem to be continuous with those of the vibratory crown (b) which enter the vestibule, are much more delicate and shorter than they; and although they perform an analogous duty in the preparation of the food before it is finally taken into the general cavity of the body, yet, inasmuch as they are occupied in the more special office of moulding the intussuscepted matter into nutritive pellets, they in all probability are to be looked upon as belonging to a separate system from those of the vibratory organ.

The so-called *bristle of the vestibule* of Vorticellidæ, which was first described as such by Lachmann (Müll. Archiv, 1856,

p. 348, taf. xiii. figs. 1–5, *eg*), *is an optical illusion*! It was almost by accident that we were induced to doubt the character of this seemingly definite body. After having successfully followed two rows of cilia from the stem of the rotatory organ into and to the very bottom of the vestibule of an *Epistylis* (*E. galea*, Ehr. ?), it seemed very strange that the "bristle of Lachmann" had not been met with during such a close and searching scrutiny. Recalling its position, as described by Lachmann and by Claparède, and as we thought we had seen it on former occasions, it was observed that, whilst one of the rows of cilia, which had just been traced into the vestibule, occupied its right side, the other row was in the position of the so-called bristle; *i. e.* it trended along the left side of the vestibule. Occasionally it was noticed that both the right and left rows of cilia had the appearance of single vibratory lashes, and that the left row, where it ran out beyond the aperture of the vestibule and thence upon the stem of the rotatory organ, had a particularly strong resemblance to a single lash or bristle, especially when the cilia projected toward the eye, so as to foreshorten the whole row. In the latter case it is easy to see how, when the cilia vibrated in regular succession, they would produce the effect of an undulating line. The closest scrutiny with a Tolles one-eighth-of-an-inch objective and a B ocular (equalling a magnifying-power of 750 diameters) utterly failed to discover the least trace of anything else which might correspond to the so-called vestibular bristle; and it was therefore fully determined upon that there is no such body existing in the vestibule of the *Epistylis*. The same observations were also made upon another species of *Epistylis* (*E. grandis*, Ehr. ?), and upon *Carchesium* (*C. polypinum*, Ehr.) and *Vorticella* (*V. nebulifera*, Ehr.), with the same result.

Notwithstanding this forewarning, it was very difficult to dispel the illusion when the vestibular cilia of *Trichodina* were under investigation. If one observes attentively, however, it will be noticed, in the first place, that what appears to be a single cilium or bristle never projects beyond the *tips* of the cilia, which lie outside of the aperture of the vestibule; and secondly, that when the tips of these cilia are followed along with the eye the row appears to terminate abruptly, and exactly at that point there seems to be the end of a bristle; *i. e.* the tip of the latter ends just where the line of ciliary points terminates; *the two are coincident*! Sometimes the point of coincidence is seen opposite the left side of the vestibular aperture, at other times opposite the middle of the same, or considerably to the right of it. Again, this point of coincidence appears to run rapidly from left to right, and then back again from right to left, as if the

tip of the bristle were sweeping along the row of cilia and pushing them back in succession. In addition to this, it will be noticed that the end of this false bristle varies in thickness from moment to moment during the shifting of the point of coincidence; and finally it may be remarked that it frequently seems to be broken into a series of dots, or short irregular pieces. This last feature gives the clue to the mystery. The apparently disjointed pieces of the tip of the false bristle are nothing more or less than the foreshortened points of the closely approximated successive cilia as they project towards the eye during the descent of the row into the vestibule. The point of coincidence mentioned above is the place where the row bends abruptly towards the aperture of the vestibule; and the shifting of this point is the changing of the trend of the ciliary tips. The line of attachment of the cilia is not changeable, and it may be readily traced to the bottom of the vestibule; but the cilia, whilst projecting at various and constantly diversified angles from their base of attachment, are so disposed that their approximated tips form a frequently varying undulating line. That the "bristle" sometimes unaccountably disappears during observation, arises from the fact that the cilia have so changed their position that they do not afford a view which presents the appearance of such a body. Usually, however, the cilia are curved transversely to the axis of the vestibule, so that they form as it were a cylinder of juxtaposed hoops or circles; and it is not to be wondered at, therefore, that in almost any position the outline of this cylinder should appear as a single line or filament. In a view directly into the aperture of the vestibule the bristle, so called, is not to be seen, for the very reason that the cylinder is presented endwise; and on this account, too, the vestibule appears to have a double contour, the inner one of these contours being nothing less than the series of curved cilia placed closely side by side and trending transversely to the axis of the cavity in question. This is a particularly facile observation in *Vorticella*, and none the less so in *Carchesium*. Finally, it may be said on this point—and, coming last, it is of no less importance than what has preceded, but, on the contrary, is worthy of the utmost consideration in an optical point of view—that were the so-called bristle a genuine body it would be in focus at only one particular adjustment of the lens; whereas we find that, having obtained what appears to be a clear and definite view of a filament, it does not go out of view by a change of the focus over a considerable extent above or below that horizon. This, one may readily perceive, would be the case in observing the outline of a transparent cylinder; and as the closely approximated curved cilia form such a cylinder,

the outline of the latter is likewise as variable as that of any other similar form.

§ 5. The Locomotive Organs.—The locomotive organs are divided into three quite distinct sets, and appear to have as many diverse offices. They are all situated at the extreme posterior end of the body. Taken in their order, they stand thus:—1st, a veil, or membranous annular margin (f, f^1); 2nd, a row of vibratile cilia (g), which lies immediately behind the veil; and 3rd, a complex "adherent organ," in the form of a circle of centrifugal hooks (figs. 10, 17, 18, h) and centripetal rays (i) which are firmly attached to the truncate posterior face of the body.

The *velum* (f, f^1) is merely an excessively thinned margin of the abruptly expanded, truncate, circular base. It has a breadth which is at least one-third as great as the length of the vibratile cilia (g), which are attached in a single row immediately behind its basal edge (fig. 17, f^2). The free edge (f^1) of the *velum* is smooth and regularly curved. It is not very difficult to distinguish from the closely set row of cilia (g) just posterior to it. Although these cilia move so uniformly in concert, or in regular succession, as to appear at times like a vibrating frilled margin (fig. 10), yet when they are nearly quiet the veil may be distinctly seen (especially with a one-eighth-of-an-inch objective) as an overlying, separately undulating membrane. With oblique light, at about twenty degrees from direct illumination, the velar edge is very conspicuous, and may be seen to be margined by a thickening (fig. 17) which is easily traced across the whole width of the body, and at a decidedly different focus from that in which the bases of the vibratile cilia underlie it. In a profile view it may be recognized as an abruptly terminating, marginal, tongue-like projection, vibrating by fits and starts (fig. 11, f), at the periphery of the circular base.

The *basal vibratile cilia* (g) form a complete, symmetrical circle about the truncate posterior end of the body. They are more delicate and much longer than those of the anterior vibratory crown (b), and arise, in a single, closely set row, from a slightly projecting annular ridge which immediately subtends the line of attachment of the *velum*. This annular ridge, as will be seen presently, is the border (figs. 10, 17, l^1) of the adherent organ. Owing to their excessive fineness, the close proximity in which they are set, and the almost uniform succession with which one cilium follows the other in the series of vibrations, this system gives to the unaccustomed eye the impression of an undulating fringe-like membrane, when it is viewed with only a moderate magnifying-power; but with an amplification of five hundred diameters, if the objective be a

good one, one may trace the cilia to their very bases, with the perfect confidence of not having seen amiss, and at the same time satisfy himself conclusively that they are unequivocally distinct from the veil which lies in front of them. There can be no hesitation, therefore, in pronouncing the veil and the vibratile row of cilia to be two distinct and separate systems, with no connexion whatever other than a close proximity of attachment to the basal margin of the body, and their similar duties in the process of locomotion*.

The *adherent organ* (figs. 10, 17, *h*, *i*, *l*) is a complex apparatus, which altogether forms a thin circular disk, whose border (l^1) reaches to the margin of the base, or, in other words, to the inner edge or line of attachment (f^2) of the *velum* (*f*).

About one-third of the radius of the adherent organ, at the peripheral margin, is occupied by a *striated annular membrane* (l, l^1, l^2, l^3, l^4, l^5), which is separable from the rest of the apparatus. It lies in *front* of the centrifugally projecting hooks (*h*), but closely pressed against them, and extends centripetally (to l^3) as far as their bases. This membrane is possessed of two sets of *striæ*, which radiate from its inner to its outer margin. *One set of striæ* occupy the anterior face (fig. 17, l^1 to l^4), and are comparatively quite coarse (l^2), and in number about ninety-six, *i. e.* four times the number of the hooks (*h*) of this organ. They lie wide apart, and are arranged so uniformly that two traverse the interval between every two hooks, and two overlap every hook, where they run to the proximal margin (l^3) of the membrane. In dead or dying specimens this membrane becomes folded or wrinkled (fig. 16, l^1) transversely, and then these *striæ* (l^2) overlap each other and appear to fork more or less, or seem to be linear processes, divergent from the curved ends of the hooks (*h*)†.

* See the note on the "adherent organ" at the end of this section, p. 415.

† In the 'Proceedings of the Boston Society of Natural History' for November 6, 1850, p. 354, Prof. L. Agassiz makes the following statement in regard to the relation of *Trichodina* to the *Medusæ*, and especially in reference to these apparently forked, radiating striæ, which remind one of the numerous radiating tubes of certain Hydroid Acalephæ. He says:—"These parasites at times leave the *Hydra* and swim free, changing their form in a remarkable degree. In addition to the internal ring, he was able to trace rays going from the hooks to the margin, divided into numerous branches, and also rays proceeding toward the centre from this ring; the margin has a fringed undulating edge, under the tentacles. By feeding them with colours, he was able to see that the internal folds are the margin of a mouth, as in *Rhacostoma*; so that these parasites on *Hydra* are diminutive *Medusæ*. In the egg of *Hydra*, he had been able to trace all the forms from a segmental yolk to these parasites; the freshwater *Hydra* is the Polypoid form of *Medusæ*, while these parasites are the Medusoid form."

The other or *posterior set of striæ* (l^4, l^5) is much more readily detected than the anterior one, and the *striæ* are about three times as numerous. They are so closely set together that it is a difficult matter to count them, although viewed with a one-eighth-of-an-inch objective. They extend, like those of the anterior set, over the whole breadth of the membrane, and, terminating abruptly at the peripheral margin (l^1, l^4), give to the thickened edge a milled appearance. This milling is, moreover, rendered conspicuous by an incrassated, scalloped border (l^1), in which the striæ (l^2) of the front set terminate*. The striated membrane is very flexible, and is frequently made to undulate, apparently by the successive impacts of the vibrating cilia.

The apparently most important members of the adherent organ are the *hooks* (h). They vary in number from twenty-two to twenty-four, and curve in a direction which is diametrically opposite to the upward coil of the vibratory organ; *i. e.* they are *læotropic*. They are *separate pieces*, of an £-formed (fig. 18, h, h^3) shape; the upright part of the £ being the *hook* (h) proper, and the horizontal limb (h^3) the base of it. These £'s are arranged in a circle with their horizontal limbs all pointing one way—*i. e.* the same as the upright part or hook—and nearly or quite touch each other, according to circumstances. A spur-like, slender point (h^2) projects from the horizontal part, in the opposite direction, and is about half as long as the latter. Along this spur and the convex side of the hook a broad, lunate crest (k) arises, and, nearly filling the interval between two succeeding hooks, projects peripherally beyond the tips of the latter. This crest is excessively faint, and not recognizable as a distinct body unless the striated membrane is removed; although it is to be

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If this be true, then the whole group of Vorticellidæ (from which no one would for a moment think of separating *Trichodina*) must be removed to the class of Acalephæ! We must, for own part, however, unequivocally dissent from this view, since it is quite at variance with our own observations. But, again, according to another, more recent statement of Prof. Agassiz, in his 'Essay on Classification' (Boston, 1857, p. 72; London ed., 1859, p. 108), he has satisfied himself of the "propriety of uniting the Vorticellidæ with Bryozoa," *i. e.* the group of Vorticellidæ; and consequently the *Acalephan* (*vide* preceding paragraph) *Trichodina* is Molluscan! From this view, also, we would modestly, but unequivocally, dissent, not only as the result of our own investigation, but in accordance with the observations of other very competent authorities. This view would also seem to argue that the Bryozoa—if they do not strictly belong, with Polypi, to the division Radiata, as is insisted upon by other and eminent authority—are at least a transitional group between Radiata and Mollusca.

* The separation of these two sets of *striæ*, or radiating ridges, is an excellent test of the quality of a quarter-inch objective; a one-eighth-of-an-inch lens can do it easily.

seen when in place, especially where it projects beyond the tip of the hook, and forms with the others a succession of scallops (fig. 17, *k*) lying in a circle parallel with the margin (l^1) of the striated membrane.

Immediately within the row of hooks a series of *nail-shaped pieces* (i^1, i^2) extends in a circle, and they are arranged in such order that each one lies opposite the horizontal part (h^3) of a hook. The pointed, conical head (i^2) of the nail-shaped piece corresponds in position with the point of contact of the bases of two successive hooks, and at the broadest part protrudes sideways between the latter. The tip of the nail-head projects between the point (i^4) of the succeeding nail and the base (h^3) of a hook, the two latter constituting a sort of socket in which the former appears to slide. This would seem to show conclusively that this complicated ring may be enlarged or diminished at the will of the animal.

The faint radiating ridges (*i*) which occupy the central two-thirds of the adherent apparatus are attached one by one to the point (i^4) of the nail-shaped body just mentioned, and at right angles to it. The basal third of these *radii* is easily seen with a one-fourth-inch objective; but even a one-eighth does not distinctly trace the pointed end to the centre of this apparatus. Each *radius* (*i*) and the nail-shaped body (i^1, i^2) seem to form a solid piece, a sort of Greek Γ whose angle is occupied by a *faint membrane*, or web (i^3), which extends from one-third to one-half the way along the nail, and nearly, or altogether, to the end of the tapering radius. This faint membrane appears to fill the whole space between the *radii*, in healthy animals.

In dying specimens the adherent organ readily separates from the body, *en masse*; but shortly afterwards the striated membrane loosens from the circle of hooks; and in a brief space of time the latter becomes disjointed, and each hook detaches from its fellow, but remains for a longer period in conjunction with its corresponding radius and nail-shaped piece *.

* Various opinions (and all of them at variance with the one promulgated in this paper) have been expressed in regard to the nature of the adherent apparatus and its motory appendages, the vibratile row of cilia. Siebold (Zeitschr. für wissenschaftl. Zool. Bd. ii. p. 367), as the following translation shows, has mistaken the row of vibratile cilia (*g*) for an *undulating membrane* and has entirely overlooked the *velum* (*f*). He says, "Among the Infusoria, the genus *Trichodina* is endowed with a distinct, undulating membrane, which, applied to the lower margin of the body, in the form of a circle, adheres to, and is supported by, a solid toothed apparatus not unlike a watch-wheel. In *Trichodina pediculus* this vibrating border is entire-margined; in *T. mitra* .... the free border of this appears to be deeply and delicately fringed. Trembley, Goeze, O. F. Müller, Carus, Dujardin, and others have, in consequence of an optical illusion, considered this undulating membrane in *T. pediculus* to be a vibrating-cilia-crown."

§ 6. The Digestive System.—This infusorian takes so readily to an indigo diet that the process of collecting food and forming it into pellets at the bottom of the œsophagus and its passage into the general cavity of the body may be seen at any time, and without any particular preparation. On this account it is no difficult task to ascertain the position of the mouth and the trend of the vestibule and œsophagus, as well as the posterior termination of the latter.

The *vestibule* (*v*) is as distinct from the œsophagus (*o*) as in most of the Vorticellidæ. Its aperture (*m*) is very broad, and diverges almost insensibly into the peristome (*d*). It passes into the body in a direction which is in strict continuation (fig. 13) of the spiral trend of the border (*d*) of the disk; that is to say, it winds posteriorly, dorsally, and toward the

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Stein (Infusionsthiere, 1854, p. 176) controverts the assertion of Siebold, and insists that the "undulating membrane" of the latter is a crown of cilia; but yet, as in Siebold's case, the *velum* has entirely escaped his notice. He writes as follows:—"The posterior cilia-crown . . . on account of the very closely set cilia, does certainly readily produce the impression of an undulating membrane margining the rear-body, which, not only in *T. mitra*, but also in *T. pediculus*, appears to be denticulately notched; but let one kill the animal with diluted acetic acid or alcohol, and he will separate each single cilium sharply. That the posterior cilia-crown is connected neither with the toothed horn-ring nor with the annuliform membrane, let one convince himself thereof by crushing the animal, by which one easily separates the entire adherent apparatus, in all its integrity, from the body."

Next Busch (Müll. Archiv, 1855, p. 358) appears in the field of controversy, and, commenting upon the observations of the two foregoing authors, makes a compromise between their views by uniting the vibratile cilia to the edge of the undulating membrane. This idea is set forth in the following words:—"On the so-called hind body is found the (by Stein first very correctly described) saucer-shaped rim, on whose base is fastened the ring of the rigid-bâton crown, from which the hooks arise. On the foundation of, and exterior to, the saucer-shaped membrane is implanted the chief locomotive organ of the animal, the posterior cilia-crown. Siebold has explained this as an undulating membrane, whilst Stein has evidently recognized the separate cilia of the same, and only speaks of a cilia-crown. The truth seems to me to lie intermediate; for though I clearly observed the single cilia, especially in dying animals, yet I could never follow them to the margin of the saucer, unless a fissure was present. This organ consists, then, of a membranous undulating border, on whose free edge vibratile cilia are inserted. One may convince himself best of this on dying animals, where one sees the gentle pulsations of the border and the cilia." Although it is certain that Busch did not see the velum, as such, and in its proper relations, yet it is not equally clear that he did not have it in view, but confounded it with the row of vibratile cilia which underlie it.

Finally, as the latest investigator, Claparède (Études sur les Infusoires et les Rhizopodes, Mémoires de l'Institut Genèvois, 1858–59, p. 130) sustains the view of Stein, demurs to the opinions of Siebold and Busch, and says nothing about the true *velum*.

right side of the body. In an end view (fig. 13) of the animal, the vestibule narrows rapidly from its aperture to its bottom, whereas when seen in profile (fig. 8, *v*) the diminution of its diameter is more gradual. When the body is fully expanded, its aperture (*m*) is always open, and is circular, or broadly oval (fig. 12, *m*), in outline. This aperture lies just behind and exterior to the first spiral turn (fig. 11, b^1 to d^5) of the vibratory margin of the cyathiform disk, and receives the termination (fig. 13, b^2) of that spiral within its depths. It might therefore, with propriety, be designated as the internal prolongation of the disk.

The anus (Pl. IX. figs. 12, 13, *a*).—When the anus is open, which not unfrequently happens, it appears as a distinctly bounded, seemingly margined aperture, which lies very conspicuously on the right side of the vestibule, and near its mouth.

The *œsophagus* (*o*, o^1), in conjunction with the vestibule (*v*), is an elongate-sigmoid (fig. 13) funnel-shaped cavity, which extends obliquely backwards and across the body, nearly to its axis. When not in the act of taking in food, the œsophagus terminates in a fusiform point or pharynx, and may be recognized as a clear colourless space in the midst of the light-yellow tissue of the body. From the point where it joins the bottom of the vestibule it curves to the left, and thus forms the dorsal termination of the sigmoid. In a profile view (fig. 8, *o*, o^1) it lies nearly parallel with the proximate or ventral surface of the body. When the pellets of food are forming, its posterior fusiform termination (o^1)—the so-called pharynx—gradually expands into a globular cavity, which eventually exceeds in diameter the breadth of the mouth; but as soon as the food passes into the general digestive cavity, it assumes its accustomed funnel-shaped outline. As has already been stated in the section on prehensile organs, it is lined by vibratile cilia, which, it may be added here, seem to cover its whole interior.

The digestive cavity.—Beyond the œsophagus there is no special cavity for the preparation or assimilation of food; the latter passes from the posterior end of the former through a simple expansible aperture directly into the general digestive cavity. The final assimilation of the food is accomplished, as in all other Vorticellidans, in a space which embraces every part of the body except that which is immediately occupied by the contractile vesicle (*cv*) and the reproductive organ (*n*). This space, therefore, serves both the purpose of a stomach and intestine; nor does it appear to have any accessory glands or appendages of whatever kind that may assist in the process of digestion.

The *walls of the body*, therefore, form the immediate parietes

of the digestive cavity. There are, at least, two of these walls. The inner one (p^1) consists of a clear, amber-coloured, homogeneous, formless tissue, in which all the organs are imbedded. The other, or *exterior wall* (p), embraces the inner one like a film, and has more of the character of a colourless excretion than a true tissue. It is thickest about midway between the two ends of the body, and gradually thins out to an inconspicuous stratum at the anterior and posterior borders. Its surface is beset with excessively minute, short cilia, which, although occasionally and with great difficulty seen to move, cannot be called vibratile cilia in a strict sense, but rather pointed roughenings which are agitated by the varied contractions and expansions of the tissue from which they arise. The thickness of this wall is more or less deeply corrugated, principally in a longitudinal direction (fig. 14, *r*, *r*), and to a certain extent independently of the irregular folds and furrows on the outer surface of the inner wall *.

§ 7. The Circulatory System.—It would seem a little remarkable, at first thought, that the Vorticellidæ, which hold the highest rank among Infusoria, should possess a circulatory system which, in all but one genus, seems as simple in character as that of the lowest forms of the class, and apparently much less complicated than in *Stentor* and *Paramecium* and others of the læotropic division. If, however, we look upon the numerous contractile vesicles of *Amphileptus*, *Trachelius*, &c., as indications of a diffuse, lowly organized circulatory system, and upon the fewer branching vesicles of *Paramecium*, *Spirostomum*, *Stentor*, &c., as tendencies to a greater degree of concentration, then the unique contractile organ of Vorticellidans would represent the consummation of this process, and consequently the most elevated status of the system as it exists in this class of animals.

The *contractile vesicle* (*cv*) of *Trichodina* is a simple cavity which lies near the ventral side (figs. 8, 11) of the animal, a little to the left of the axial plane (figs. 12, 13), and consequently on the same side of the œsophagus, and about halfway between the anterior and posterior truncate ends of the body†. It contracts once in fifteen seconds. The systole occupies

* See, for further details, the section (§ 3) on the *form* of the body.

† There is a singular error in Stein's figure (Infusionsthiere, 1854, taf. vi. fig. 56) of the animal as seen from the basal end. The view of the base is underlain by a view of the anterior end of the body; but the latter is posited *as if seen from the front*. To correct it, the contractile vesicle should lie to the right of the œsophagus, and the sigmoid flexure of the vestibule and œsophagus should be reversed.

between two and three seconds, and the diastole proceeds slowly and continuously during the remainder of the quarter of a minute, until the vesicle has attained its maximum size (figs. 8, 11, 13, 14), and then it immediately contracts again. In specimens which are confined, or in the least restrained in their movements, the systole and diastole succeed each other much less frequently. At the full diastole the vesicle is perfectly globular, and occupies at least one-third of the diameter of the mid region of a fully expanded animal. The systole reduces it to an almost invisible point; and from this it gradually expands, first into a jagged (fig. 10, *cv*) star-like cavity, then into an irregular spheroid (fig. 12), and finally assumes, at full diastole, a globular contour.

§ 8. The Reproductive System.—As these observations extend over but a few days (mostly at the beginning of October of this year), the different phases in the development of the *nucleus* were not investigated. At the period just mentioned, this organ (n, n^1) had the form of a thick, knotted, or moniliform band, which extended in a uniform curve, over three-quarters of a circle, around the truncate base, and in a direction exactly transverse to the axis of the body. Its two ends (n^1) lay next the ventral side, and right and left of the plane which passes through the œsophagus; and its breadth ran parallel with the axis of the body. It had a decidedly yellow colour, and was finely granulated throughout. In profile, or rather in a foreshortened view of its length, it was quite conspicuous; but where it extended across the vision, it was so excessively faint as to nearly escape the eye, even though the utmost care was taken to ascertain its presence and exact position.

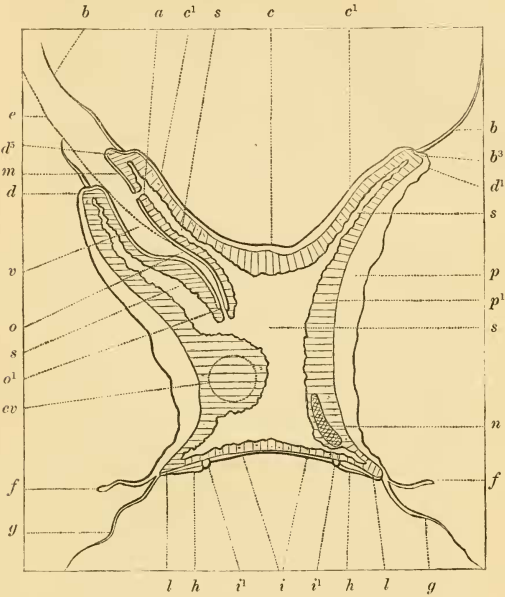
§ 9. Résumé*.—Reducing, now, the details which have been given in this memoir to the briefest expressions, we have the following summary in an aphoristic form. In its healthy, unrestrained condition, *Trichodina pediculus* is very dissimilar to the hitherto published representations of it. The illustrations of Ehrenberg, Dujardin, Stein, and Busch represent the animal in an abnormal, more or less *reverted* attitude, the result of studying the animal in a confined state, or when in an unhealthy condition. It has a deep, cyathiform, or dice-box shape, with an irregularly and longitudinally furrowed and plicated exterior. There is no *disk*, or it is represented by the depressed cupuliform area which is bordered by the *vibratory crown*. The *peristome* is not a closed circle, as in Vorticellidæ proper, but

* The principal points of this *résumé* are to be found in the 'Proceedings of the Boston Society of Natural History,' Oct. 18, 1865.

follows the spiral course of the vibratory crown, and vanishes near the aperture of the vestibule. The *vibratory crown* consists of a single row of vibrating cilia, which winds along the margin of the spiral dexiotropic peristome, just at the edge of the cupuliform disk, and descends thence to the left of the vestibular aperture, and, entering it, plunges to the bottom of the vestibule in an unbroken line. Neither *Trichodina* nor any of the Vorticellidæ possesses a vestibular lash or bristle; and the latter is an optical illusion. The posterior truncate end of the body is margined by a well-defined annular *velum*, immediately behind which, and arising from the same basis, is a complete circle of vibrating cilia. The so-called *adherent organ*, or apparatus of hooks and *radii*, consists, *first*, of a distinct, separable, annular border, whose opposite faces are dissimilarly striated by perfectly straight, transverse ridges; *secondly*, of a complicated circle of disseverable hooks, which are applied to the *posterior* face of the striated annular border, along its proximal edge; and *thirdly*, of a series of Γ-shaped radii, which lie one by one opposite the several hooks, and converge toward the axis of the basal plane of the body. The vestibule and œsophagus are as well marked, each in its own way, as in any of the Vorticellidæ. The vestibule opens near, and posterior to, the cilia-crowned margin of the sunken cupuliform disk. The anus opens into the vestibule a short distance from its mouth, and on the right side. The contractile vesicle is a simple cavity, which performs its systole *once in fifteen seconds*. The reproductive organ is a knotted band whose antero-posterior thickness is much greater than at right angles to that; and it lies, in the form of a crescent, near the base and transverse to the longitudinal axis of the body.

The extraordinary and almost incomprehensible position and form of the disk of this singular appendage of the Vorticellidan group seem to render it desirable that no pains should be spared to make the relations of its organs to each other as clear to the understanding as it is possible to do with the help of figures. The accompanying diagrammatic illustration of a longitudinal, sectional, or rather profile, view of *Trichodina pediculus* is particularly intended to exhibit the outline of the sunken cup-shaped disk (c, c^1) and its close connexion with the peristome (d^1, d^5); but, in addition to this, it is designed to show, in an outline sketch, the relations of the internal organs to the walls of the body. The contractile vesicle (cv), not being strictly in the plane of the section, is represented in dotted outline. The nucleus (n) is cut across its middle. The sigmoid figure of the

vestibule (*v*) and œsophagus (*o*), being seen as it were edgewise, is foreshortened upon a flat surface. The lettering is the same as that used for the figures of the plates.



EXPLANATION OF THE PLATES.

The corresponding parts in all the figures of the plate and the woodcut are lettered alike as follows:—*a*, anus; *b*, vibratory crown; b^1, beginning of the vibratory crown; b^2, end of the vibratory crown within the vestibule; b^3, furrow of the vibratory crown; *c*, the bottom of the cupuliform disk; c^1, the side of the disk; c^2, the side of the disk rolled back; c^3, a front view of the disk; c^4, the "inclined plane" which lies upon the cornice-like oblique projection below the aperture of the vestibule; *cv*, the contractile vesicle; *d*, the peristome opposite the vestibular aperture; d^1, the dorsal region of the peristome; d^2, the inrolled edge of the peristome; d^3, the peristome at the edge of the inclined plane (c^4); d^4, the peristome where it becomes blended with the general surface of the body; d^5, the first turn or ventral region of the peristome; *e*, the lumen of the edge of the row of vibrating cilia, hitherto supposed to be a distinct vestibular lash ("bristle"); *f*, the profile of the *velum*; f^1, the free edge of the *velum*; f^2, the basal edge or line of attachment of the *velum*; *g*, the basal

cilia-crown; *h*, the hooks of the adherent organ; h^1, the circle formed by the bases of the hooks; h^2, the spur of *h*; h^3, the horizontal limb of the hook; *i*, the *radii*; i^1, the "nail-shaped piece;" i^2, the head of the same; i^3, the "*faint membrane*" or web of the Γ-shaped radii; i^4, the point of the nail-shaped piece; *k*, the crest of the hooks; *l*, the profile of the "striated membrane;" l^1, the distal edge of the last; l^2, the coarser striæ of the same, on its front face; l^3, the proximal edge of the same; l^4, l^5, a portion of the posterior face of the striated membrane, showing the finer striæ; *m*, the mouth of the vestibule; *n*, the nucleus, or reproductive organ; n^1, the left end of the nucleus; *o*, the œsophagus; o^1, the bottom of the same; *p*, the outer, and p^1, the inner walls of the body; *q*, digestive vacuole; *r*, longitudinal ridges on the surface of the body; *s*, the general digestive cavity; *v*, the vestibule.

All the figures represent the whole or portions of *Trichodina pediculus*, Ehr.

Plate VIII.

Fig. 1. An individual in the fullest degree of expansion. This is the most common form of the animal. 200 diameters.

Fig. 2. Another, less frequent form of a fully expanded individual. 200 diam.

Fig. 3. An attitude occasionally, but briefly, assumed by healthy specimens. The body is simply shortened, but without changing or reversing the relative position of the organs. 200 diam.

Figs. 4 & 5. Shapes assumed when swimming, different from those already described. 200 diam.

Fig. 6. An individual with the edge of the cup-shaped front (disk) rolled back so as to expose the bottom of the cup. 200 diam.

Fig. 7. A partially retracted individual, with one side of the cupuliform front rolled back. 200 diam.

Fig. 8. A profile view of the left side, showing the following parts: viz., the left flank (c^2) of the front partially reverted, and the right flank in the distance bearing the vibratory crown (*b*); the bottom (*c*) of the cupuliform disk in the distance, and its flank in profile (c^1); the contractile vesicle (*cv*), at full diastole, lying near the ventral side of the body; the peristome (*d*) opposite the mouth (*m*), *i. e.* where the cilia—of the vibratory crown (*b*)—leave it and enter the vestibule (*v*), also the profile (d^1) of the same at the dorsal margin; the falsely called vestibular lash (*bristle*) (*e*) apparently attached near the dorso-anterior side of the vestibule; the *velum* in profile (*f*), and nearer the observer (at f^1) overhanging the base of the posterior row of cilia (*g*); the ring (h^1) of hooks of the adherent organ foreshortened, *i. e.* seen strictly edgewise; the left half (n^1) of the nucleus most conspicuous next the back, where its length is foreshortened; the œsophagus (*o* to o^1), partially filled by a nutritive pellet in the process of formation and rapidly revolved by the action of the vibratile cilia; the filmy, colourless outer wall (*p*) projecting very conspicuously in profile, and in marked contrast with the bright amber-coloured inner one (p^1); the general digestive cavity, occupied by numerous "digestive vacuoles" (*q*), nutritive pellets, and smaller alimentary concretions; the wide aperture (*m*) of the vestibule (*v*), and the latter obliquely traversed by the posterior termination of the spiral vibratory crown. 850 diam.

Fig. 9. A transversely sectional view of the mid region of the body, to show its irregular contour and the corrugations of the outer (*p*) and inner (p^1) walls. 850 diam.

Fig. 10. A dorsal view of an individual whose peristome (d^1, d^2) is inrolled, and with it the vibratory crown (b), which hangs down into the enclosed space about the partially raised boss-like bottom (c) of the disk. The contractile vesicle (cv) is in partial diastole. The nucleus (n) lies next the back. The principal feature in this figure is the adherent apparatus (i, h, l, l^1), which is copied whilst in the act of embracing a highly convex surface, and has therefore an inverted saucer-shaped contour. The radii (i) are in the extreme distance; the hooks (h) project in the opposite direction; the striated membrane shows its breadth in the profile (l), and exhibits its milled edge (l^1) and the coarser striæ where it projects toward the observer. The *velum* (f) is at its fullest expansion, and allows its thickened margin (f^1) to be seen very distinctly where it overlies the gaps between the groups of vibrating cilia (g). The cilia of the basal vibratory crown are represented as they appear sometimes when moving in groups or successive waves, and when they most resemble a torn, undulating membrane. 6. 9 diam.

Fig. 11. A bird's-eye view of the left side and of the anterior end of the body, partially exposing the depressed face (c^3) of the cupuliform disk. The vibratory crown (b) is displayed throughout its length, from its beginning (b^1) on the right side, over its spiral sweep by the ventral and dorsal sides, and thence to its downward coil into the mouth (m) of the vestibule. The peristome follows the same course as the vibratory crown, and appears as a distinct rim (d^3, d^5) just outside the base of the cilia, until, after descending along the edge (d^3) of the inclined plane (c^4), it vanishes on the left of the mouth (m). The false vestibular lash (e) or *lumen* of the vibrating tips of the cilia. The *velum* (f, f^1), shown very clearly in the profile (f), projecting like a tongue, and undulating independently of the vibratory cilia (g). The circle (h) of hooks and the striated membrane are drawn but just distinct enough to show their position. The mouth (m) of the vestibule appears as an oval aperture, lying between the first (d^5) and second (d^3) coils of the peristome. The œsophagus (o) is very much expanded at its bottom by a fully formed nutritive pellet, just at the moment when the latter is about to be passed into the digestive cavity. The nucleus (n, n^1) lies fully in view, with its left end (n^1) nearest the observer, and its right half in the distance beyond the contractile vesicle (cv). 650 diam.

Plate IX.

Fig. 12. A bird's-eye view of the ventral side and front of a slightly retracted individual, exposing the dorsal flank (c^3) of the cupuliform disk. The anus (a) appears as a distinct opening (when the fæces are making their exit) at the right side of the vestibule, whose interior is here partially exposed in the full-face view of the gaping mouth (m). The descent of the vibratory crown along the edge (d^3) of the inclined plane (c^4) is its most noteworthy feature in this view. Its beginning (b^1) on the right side of the front is also clearly brought out. The dorsal flank (c^3) of the cup-shaped disk presents an unobstructed view, but its bottom (c) is seen in profile through the side of the body. Its extension in the form of the inclined plane (c^4) has already been noticed. The contractile vesicle (cv) is represented in partial systole, a very marked feature when contrasted with its hemidiastole

(fig. 10, *cv*). The peristome is particularly noticeable as a distinct border (d^3) along the edge of the inclined plane (c^4), and for its disappearance at the left side of the mouth (m). The pseudo-vestibular lash (e) or tips of the vibrating cilia raised above the position which they usually occupy, and in the attitude assumed during the expulsion of the fæces. The *velum* (f, f^1) is only partially expanded. From the position of the animal, the basal cilia (g) are exposed at full length. The hooks and radii of the adherent apparatus (h) are but dimly seen through the corrugated walls of the body. From its peculiar position in this view, the vestibule is seen through the open mouth (m). The moniliform nucleus (n) is seen in the extreme distance; its right (n) and left ends are foreshortened, and appear as two very conspicuous, dark-yellow, oval spots, easily seen even with a low magnifying-power. 650 diam.

Fig. 13. An end view of the anterior face, looking directly into the cupuliform disk (c^3), and through its walls upon the various organs. The ventral region corresponds to the lower side of the figure. The anus (a) appears as a faint slit on the right border of the vestibule (v). The vibratory crown (b) commences abruptly on the right (b^1) side, and appears clearly defined as a spiral just within the peristome (d^1), and equally well marked where it forms a curve (b^2) at the bottom of the vestibule (v). It is quite evident, from this view, that the disk (c^3) is inseparable from the peristome (d^1), except by the slight, narrow furrow from which the cilia arise. The peristome is designated by a double border (d^1) (the outer and inner walls) along the spiral course of the vibratory row (b, b^1); but at the mouth (at d) of the vestibule (v) it loses that character, and gradually shades off (at d^4) into the surrounding surface. The lumen of the vibrating row of cilia—the vestibular lash (e) falsely so called—appears distinct from this point of view. The contractile vesicle (cv) is in full diastole. Its distance from the ventral side of the body is rendered apparently unusual by the expanse of the disk (c^3). The circle (h, h^1) of hooks and the *radii* are in the extreme distance, the hooks partially overlain by the knotted nucleus (n, n^1) and the œsophagus (o). The œsophagus (o) is in a scarcely expanded state, having but a few granules within it. The principal feature is its decidedly marked curve in the opposite direction to that of the vestibule (v). The "digestive vacuoles" (q, q) lie nearest the observer. 650 diam.

Fig. 14. A dorsal view of the body. The læotropic leaning of the cilia (b) of the vibratory crown is more decidedly marked than in the previous figures. The bottom (c) and flank (c^1) of the cup-shaped disk are seen in strict profile through the corrugations (r) and furrows of the outer (p) and inner (p^1) walls. The contractile vesicle (cv) is in the extreme distance, at its full diastole. The peristome (d^1) appears as a distinct ridge just exterior to the vibratory crown. The *velum* (f) is in a semi-expanded state. The cilia (g) of the basal crown are stretched to their full length. The circle (h) of hooks is scarcely recognizable as such in an edge view like this. The nucleus (n) lies next the observer. The outer wall (p), as in previous figures, bristles with numerous immobile, short cilia. The inner wall (p^1) is dotted everywhere by a minute scattered granulation. The longitudinal ridges (r) of the body bear a singular resemblance to muscles. 650 diam.

Fig. 15. A diagrammatic enlargement of the edge of the disk, principally to show how the cilia (b) arise from the furrow (b^3), and also the relation of the peristome (d^1) to the furrow. The outer (p) and inner (p^1) walls are represented in their relative proportions.

Fig. 16. A portion of the adherent apparatus, from a dead animal, to show the wrinkling of the striated membrane (l^1) and the overlapped, apparently forked, coarser striæ (l^2). The latter are seen through the thickness of the membrane, the finer striæ being omitted. The hooks (h) and radii (i) lie on the side next the eye. 950 diam.

Fig. 17. A basal view of the adherent apparatus, velum, and a part of the posterior row of cilia. The hooks (h) with their crests (k) lie nearest the observer, and partially covering the striated membrane (l^1 to l^5). The radii (i, i^1) with their webs (i^3) fill up the central area. The posterior face of the striated membrane with its finer striæ is shown from l^4 to l^5, and the anterior face of the same, as seen through its thickness, with its coarser striæ (l^2), between l^1 and l^4. The distal edge (l^1) is crenated and thickened. The proximal edge (l^3) runs along the bases of the hooks. The velum (f^1, f^1) is attached by its proximal edge (f^2) close to the distal margin (l^1, l^4, l^5) of the striated membrane, and almost the same with, but just anterior to, the line of attachment of the cilia (g, g) of the basal crown. Between l^5 and f^2 the striæ of the membrane are omitted. 950 diam.

Fig. 18. Two of the hooks and their corresponding radii, from the adherent apparatus of a dead specimen. The hook (h), its horizontal limb (h^3), the spur (h^2), and the crest (k) apparently form one solid piece. The *radius* (i) and the nail-shaped transverse piece (i^1, i^2) are united at the angle by a triangular web (i^3). The mechanical contrivance for the sliding of these pieces upon and between each other is too obvious to need any comment. 2400 diam.

Cambridge, Mass., October 1865.

XLV.—*Contributions to an Insect Fauna of the Amazons Valley.* Coleoptera: Longicornes. By H. W. Bates, Esq.

[Continued from p. 373.]

Genus Amphionycha (Dej. Cat.), Thomson.

Thomson, Archiv. Entom. i. p. 311.

The numerous species which compose this genus agree in the possession of long filiform antennæ, with the joints more or less densely fringed with fine hairs, but never partially thickened, clothed, or tufted; the third joint is more or less disproportionately elongated. The body is variable in shape, but is generally elongated and linear, in some species greatly elongated, in others much shorter and oblong. All have well-developed lateral carinæ on the elytra; the apices of the latter are variable, being in some species broadly truncated and toothed, in others briefly truncated, and in some species rounded and entire.